

# Retrofit Emission Controls for Off-Road Diesel Engines

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*Off-Road Implementation Advisory Group*

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[www.meca.org](http://www.meca.org)  
[www.dieselretrofit.org](http://www.dieselretrofit.org)

# Presentation Outline

- Off-road Retrofit Overview
  - Retrofit Technologies
  - Application engineering
  - Installation
  - On-vehicle monitors
  - Filter Maintenance
- Experience with Construction Retrofits
- Challenges for Construction Retrofits
- Q&A

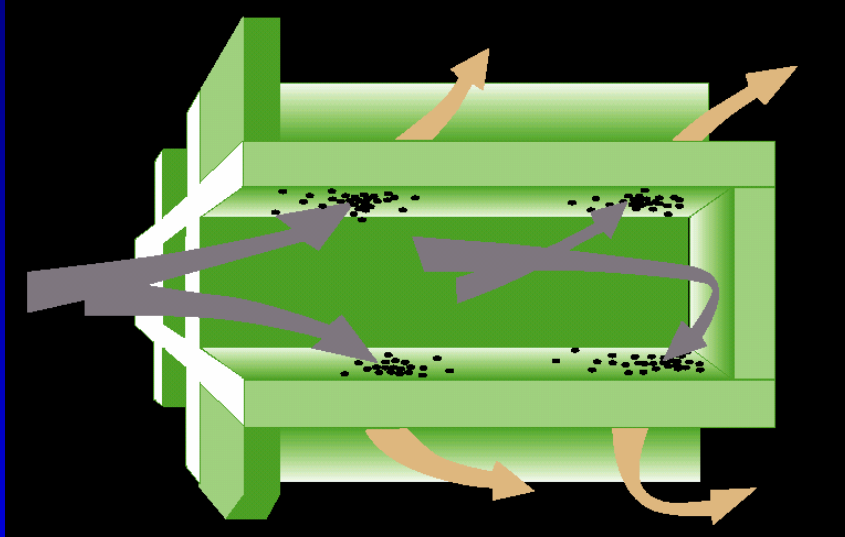
# MECA Background

- Founded in 1976 to be The Technical Spokesperson for Our Industry
- Currently 48 Members
- Member companies have over 35 years of experience and a proven track record of success in developing and manufacturing emission control technology
- Members cover diverse range of emission control technologies for both new and existing engines/vehicles:
  - Substrates
  - Catalytic converters (all fuels)
  - Diesel particulate filters
  - Exhaust components/exhaust system integration
  - Sensors

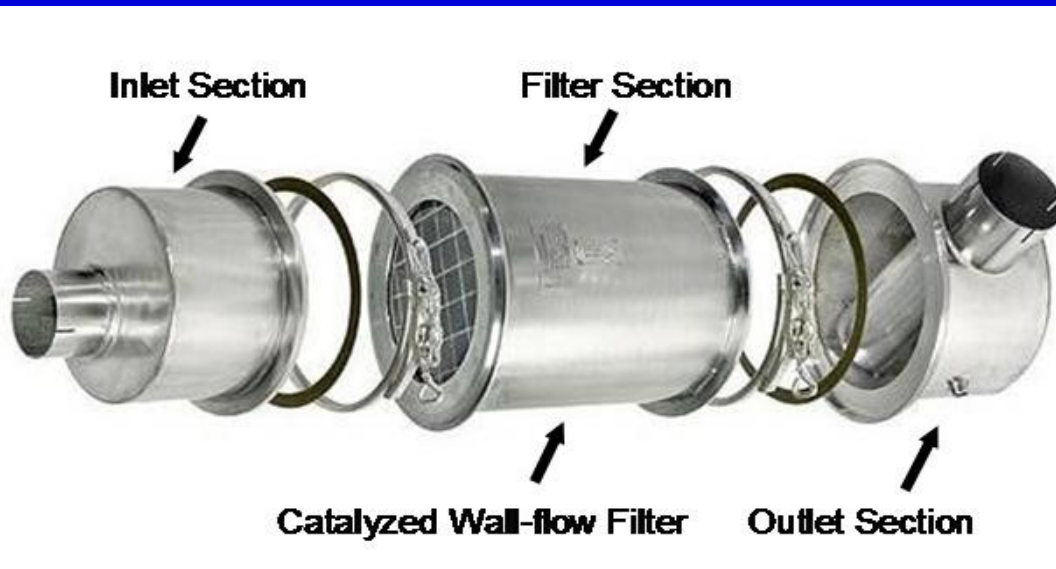
# Strategies to Reduce Emissions from In-Use Diesel Engines

- Retrofit – installing a verified emission control device on an existing diesel engine.
- Repair/Rebuild
- Repower
- Replacement

# Wall-Flow Diesel Particulate Filters Offer the Highest PM Filtration Efficiency



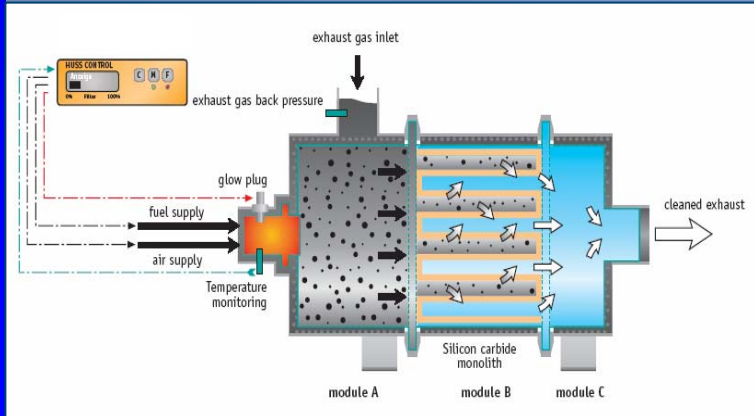
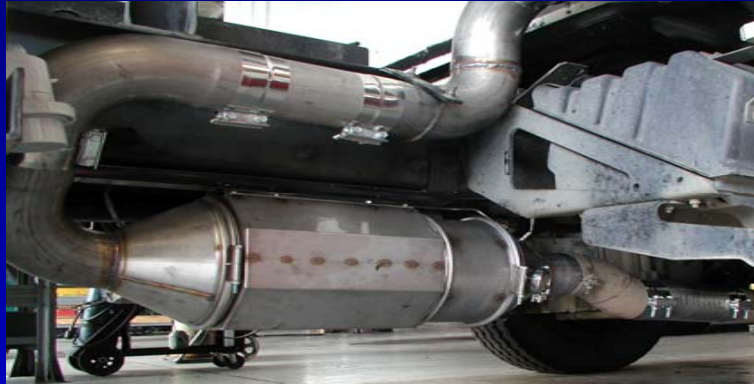
- >85% PM reduction (ARB Level 3)
- Catalyzed DPFs require operation on ULSD
- Large reduction in toxics from catalyzed DPFs
- >200,000 retrofits worldwide
- >5 million OE applications
- Same technology as on MY 2007 OE trucks



Passively regenerated DPFs employ catalysts and available exhaust heat to burn captured soot – specified exhaust temperature requirements

# DPFs with Active Regeneration

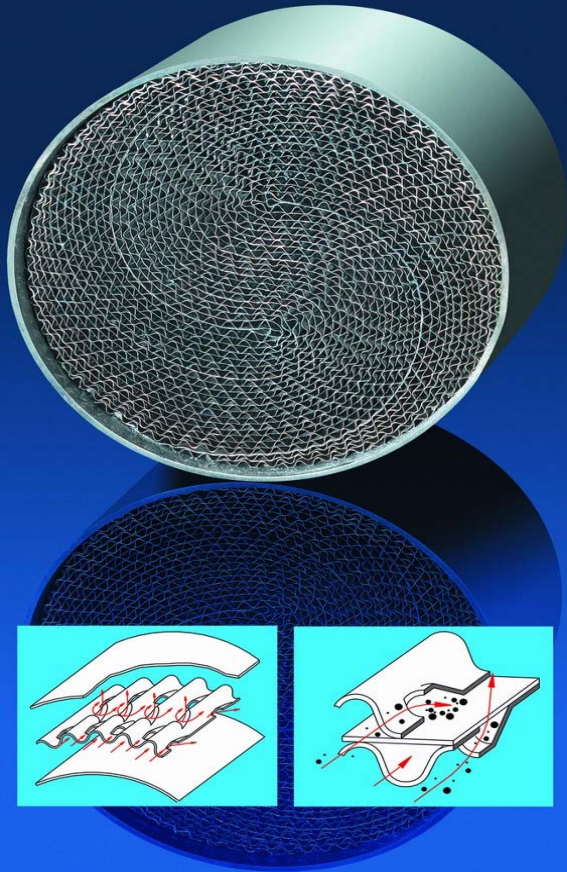
## Available for Retrofits



- Suited for on- and off-road applications with low exhaust temperatures.
- Uncatalyzed or catalyzed wall-flow filter with electrical regeneration.
- Wall-flow filter with a fuel burner for regeneration.

# Flow-Through Filter Technologies

Metal Substrate with Sintered  
Metal Sheets



Quelle: Emitec / pm\_filter\_kat1.tif

- 50-75% PM reduction (ARB Level 2)
- Can be catalyzed or used with a DOC
- Has applicability on older engines
- Resistant to plugging
- Ash cleaning generally not necessary due to open structure

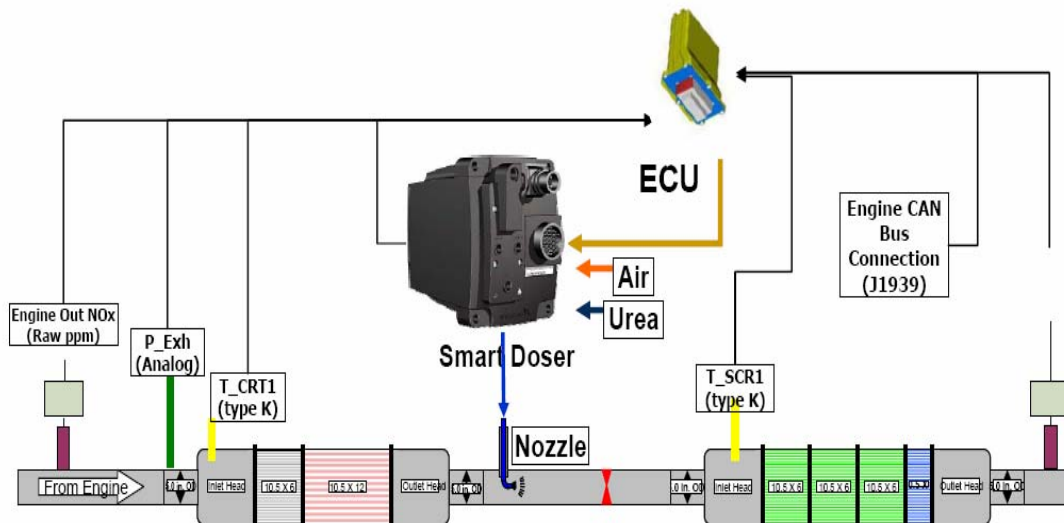
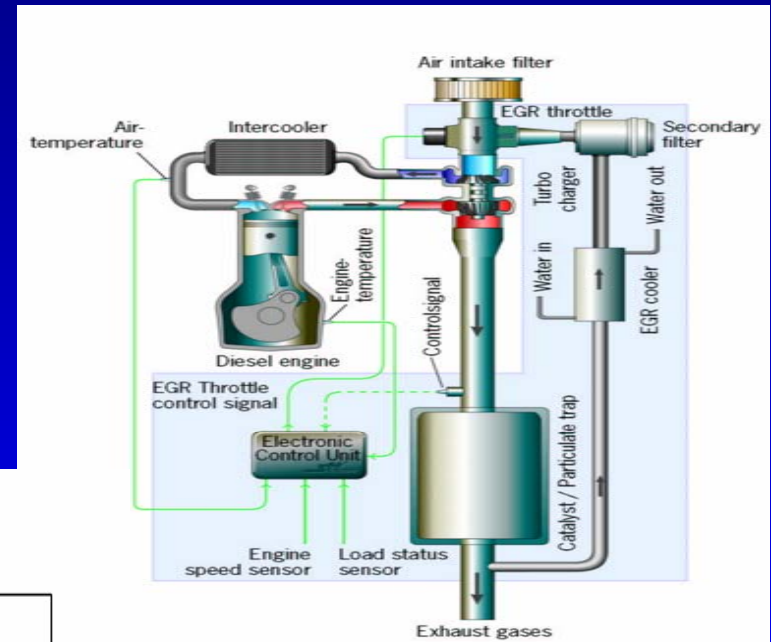


## Integrated Solutions for Combined PM/NOx Reductions Available for Retrofit

**Lean NOx Cat. + DPF**  
**– 25% NOx reduction**



## Low Pressure EGR + DPF – 40% NOx reduction



**Catalyst-based Filter + Urea-SCR Catalyst**  
**70+% NOx reduction**



# Off-Road Retrofit Installations of Integrated NOx+DPF Retrofit Systems



SCR Catalysts

DPF Filter

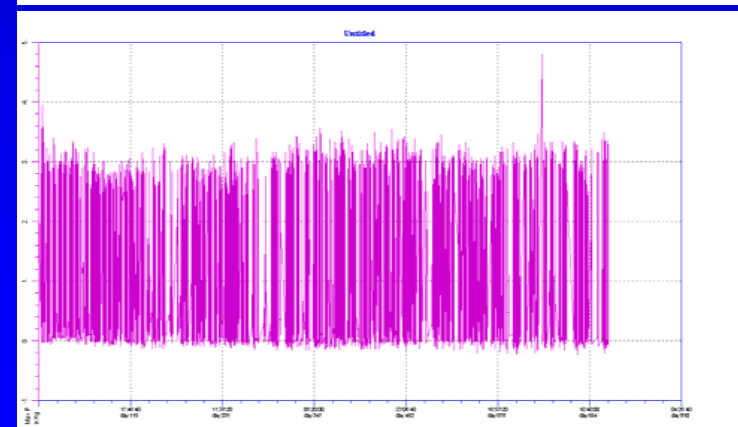
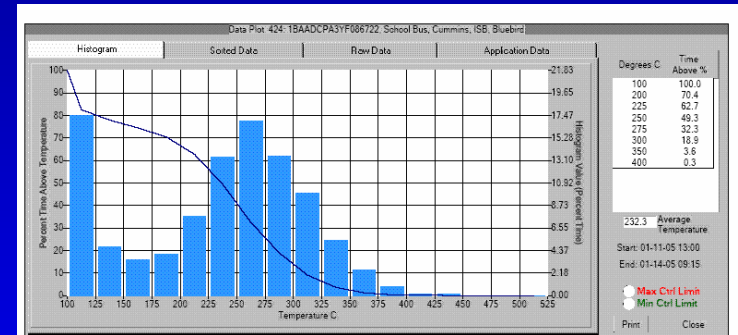
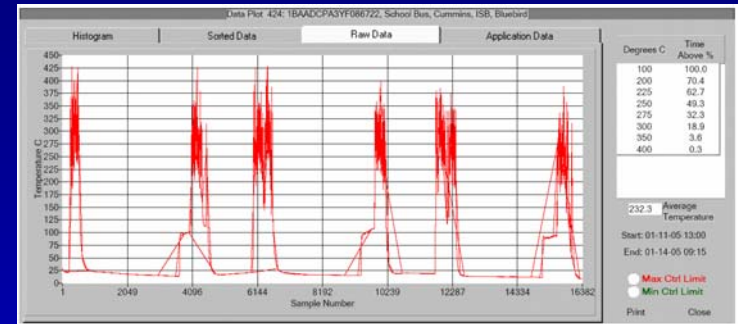


# Application Engineering Process

- Opportunity definition
  - Information profile/documentation
- Control technology assessment
  - Verification review
  - BACT review
  - Technology options
- Exhaust temperature/duty cycle for Level 2&3
  - Datalogging
  - Engine HP and exhaust flow needed for sizing
  - Analysis/feedback
- Control technology sales/installation
  - Product selection
  - Engine & exhaust configuration needed for parts selection
  - Installation
  - maintenance

# Data logging and Vehicle Monitoring

- Data logging is important for technology selection
  - Temperature profile & back pressure
- Systems come with software to allow data analysis
  - Data taken and provided to control technology supplier
- Vehicle monitoring collects real time data and alerts operator of back pressure or temperature limits
  - Multi-light displays to indicate system faults, warnings and alarm conditions





# Photos of Installed Monitors

Construction Equipment



Inside Cab



In Engine Space



In Engine Space



# Installation

- Each application is different, proper engineering judgment must be applied
- DPF's are heavier and more fragile than standard exhaust components
- Vibration must be addressed
  - Use of flex to isolate DPF from engine vibration
  - Use of vibration dampeners to isolate DPF from equipment vibrations
- Do not weld directly to DPF
- Protect filter element from water intrusion
- Wrapping the exhaust pipe upstream of the filter or thermal isolation to protect wiring and tubing may be required.
- When in doubt check with the manufacturer or representative
- Make sure you receive and protect your installers warranty

# Installation Safety

- Do not obstruct operator “Line of Sight” with installation
- Do not obstruct equipment operation
- Do not obstruct operator access
- Do not mount on safety cages without knowing the load capacity rating of the structure and how to mount to it
- Use of proper shields to avoid accidental contact with operator, or flammable materials- i.e. fuel lines, hydraulic lines, rubber hoses, etc.
- Use of proper lifting devices and techniques
- Inspect as per manufacturer’s instructions on a regular basis
- For systems with electrical components, do not use if plugs or cables are damaged



# DPF Maintenance

- Regeneration: Carbonaceous PM (Soot) collected in the filter must be periodically combusted to avoid high backpressure or damage to the filter.
  - Passive regeneration: uses a combination of exhaust heat and a catalyst to combust the soot
  - Active regeneration: uses a heat source such as an electrical heater, a flame based burner, or a catalytic burner to combust the soot
- Cleaning: Inorganic ash, which is not combustible, will collect in the DPF over time and require cleaning
- Even “passive” solutions need maintenance (e.g., filter cleaning, urea for SCR)
- Periodic inspections:
  - warning lights from backpressure monitor
  - mounting brackets & clamps
  - presence of soot in the tailpipe
  - condensation in tubing associated with pressure sensors/monitors
  - Follow vendor provided maintenance and cleaning guidelines

# Importance of Filter Cleaning

- Failure to clean a filter when necessary can potentially lead to:
  - Engine performance problems
  - Damage or destruction of the filter
  - More complex and expensive ash removal processes
- Approved filter cleaning is required:
  - To assess the filter is still in good working order
  - To maintain warranty coverage
  - To ensure safe practices around worker exposure and disposal

# Filter Cleaning Step by Step

Captured in tail pipe . . .



Collected in filter bag . . .



Sealed in containers . . .



and sent to hazardous waste facility.

# Construction Retrofit Experience

- New York City Local Law No. 77
  - Requires use of ULSD and BACT for off-road vehicles used in city construction projects
    - Croton: 34 vehicles, ADPF, PDPF, SCR+NOx
    - Manhattan: 118 Tier 1&2 with DPF
    - Catskill-Delaware: 59 vehicles
- SCAQMD/ARB demonstration projects for DPFs on construction equipment
  - LAX: 73 vehicles retrofitted with Level 3 VDECS (ADPF & PDPF)
  - Off-Road Showcase Program
    - 230 vehicles, 11 ADPFs, 19 PDPFs, 8 PM+NOx
- Texas NTRD Funding for Retrofit Verification
  - 3 manufacturers funded to demonstrate retrofit SCR systems for on and off-road applications
- European experience
  - On-line database of over 7000 pieces of construction equipment fitted with DPFs.



# PDPF: Passive Diesel Particulate Filter



Komatsu Dozer



Tamrock Tiger Drill



Komatsu Excavator



Caterpillar 966G Rubber Tire Loader



Volvo L80E Wheel Loader



Furukawa Hydraulic Drill

# ADPF: Active Diesel Particulate Filter





# Construction Retrofit Experience: NYC Croton Construction Project

- \$1.5 billion water treatment plant in the North Bronx; project extends through 2012
- Required by NY Local Law 77, All city agencies and contractors to use ULSD and verified BACT.
- 34 non-road machines (Tier 2&3), six equipment types, Compressors, bulldozers, excavators, quarry trucks, rubber tire loaders, Tiger drills.
- ARB or EPA verified retrofit technologies, including passive & active DPFs, DPF+SCR system
- Working for over two yrs. With minimal downtime.

# Equipment Emission Results

## NYC Croton Construction Project

Equipment	DECS	Emission Reduction (%)			
		TPM	THC	NOx	CO
Compressor	SCR/DPF	97	94	67	99
Dozer	PDPF	97	93	5	99
Excavator	PDPF	99	79	12	98
Terex Quarry Truck	ADPF	45	31	3	34
Rubber Tire Loader	PDPF	99	81	7	93
Tiger Drill	PDPF	99	52	5	99

*Conducted by Emisstar with Environment Canada*

*Test results following 100-200 hours of in-use operation*

*10-14 tests were performed on each piece of equipment over a pre-determined test cycle.*

# Challenges for Off-Road Retrofits

- Higher emissions than on-road heavy-duty engines
  - Uncontrolled before 1996
- More diverse engine/equipment applications than on-road
  - More older equipment
  - Wide horsepower range
  - Equipment stability
- More rigorous operating environment (vibrations, dust, uneven surfaces)
  - Can require extensive use of high-grade vibration isolators, especially in track-drive equipment
- Need for more preventative equipment maintenance
  - Air filters, injectors, and turbochargers
  - Basic inspection and maintenance of installations
- Packaging constraints
  - Maintaining driver visibility
  - Safety

# Retrofit Installation Lessons Learned

- Basic problems
  - Mis-fueling
  - Lack of preventative maintenance
    - especially air filters, injectors and turbochargers
    - basic inspection and maintenance of installations
- Underestimating vibration
  - Vibration requiring extensive use of high grade vibration isolators especially in track drive equipment.
  - Filter is ceramic “Do Not Drop”
- Interference with installation process
  - taking short cuts to get machine done now
  - Requiring on-site installation

# Key Technical Considerations for Successful Construction Retrofit Projects

- Application engineering – matching the right technology to the vehicle or equipment (Passive or Active)
  - Proper professional installation
  - On-vehicle monitors – provide important user feedback on performance
  - Maintenance – vehicle/equipment and retrofit device may require frequent inspection and maintenance
  - Retrofit technologies are generally compatible with biodiesel (typically, B20 or less; biodiesel blend needs to meet existing specifications)
  - Significant on-road & off-road experience with retrofit technologies; growing experience for many off-road applications
- **Successful Retrofits Require a Team Effort Between Fleet Owners, Operators, Technology Providers and Installers**

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## Diesel Retrofit Technology for *Clean Air*



The purpose of this web site is to provide useful information related to diesel retrofit emission control technology. By making this information available, MECA hopes to assist interested stakeholders in establishing and operating more effective diesel retrofit programs.

The **Manufacturers of Emission Controls Association (MECA)** is a non-profit association incorporated in Washington, DC. MECA's mission is to provide technical information on emission control technology, thereby facilitating the establishment of strong and effective state, federal, and international air quality programs that promote public health, environmental quality, and industrial progress.

For an overview of this website, please refer to our [Site map](#).

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